ICARUS Workshop
First Advisory Board Meeting

Consortium Welcome

ICARUS Team

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

Workshop Agenda

Chairman Andrew Hately

ICARUS Agenda	Speaker	Time	Schedule
❑ Welcome and Project Introduction	*Cristina Terpessi - E-GEOS*	10'	10:30 - 10:40
❑ ICARUS Scope and High Level Objectives	*Corrado Orsini - TELESPAZIO* *Alberto Mennella - TOPVIEW*	10‘ 10’	10:40 - 11:00
❑ Q & A session	*All*	10'	11:00 - 11:10
❑ ICARUS Digital Elevation Models & ICARUS Architecture	*Mattia Crespi - DICEA* *Pawel Korzec - DRONERADAR*	10‘ 10’	11:10 - 11:30
❑ Q & A session	*All*	10'	11:30 - 11:40
❑ ICARUS Real Time Survey	*Francesco Russo- TOPVIEW*	10’	11:40 - 11:50
❑ ICARUS Communication - video and preliminary survey data	*Manuel Onate - EUROUSC*	10’	11:50 – 12:00
❑ Open Discussion	*All*	25’	12:00 – 12:25
❑ ICARUS Roadmap & Closing Meeting	*Cristina Terpessi - e-GEOS*	5’	12:26 – 12:30

We want your feedback

- There will be a Q&A section after each presentation and a final open discusion
- If you have a question, please use the chat box at any time during the presentation and click on the hand icon to raise your hand:

- At the end of each presentation and during the Open Discussion section, the chairman will unmute your microphones, so that you can formulate your question to the speaker
- Also, remember that **the workshop will be recorded** and will be available at the private section of our website
- Please remember to send us your **Informed Consent form**, if you have not yet sent it

ICARUS Introduction

Cristina Terpessi **e-Geos**

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

INTEGRATED COMMON ALTITUDE REFERENCE SYSTEM FOR U-SPACE

SESAR 2020 "Exploratory Research" Call H2020-SESAR-2019-2 (ER4)

ICARUS project proposes an **innovative** and feasible **solution** to address the novel challenge of the **Common Altitude Reference** inside **VLL airspaces** with the definition of a **new U-space** prototype **service** and its validation in a real operational environment.

ICARUS Consortium and Expertise

Expertise	EGEOS	TPZ	TOPV	DRAD	ECTL	EUSC	POLIMI	DICEA
Project management	✓	✓	✓					
Aeronautical info management				✓	✓			
Geomatics & DTMs	✓						✓	
Ground Obstacle data base	✓							✓
GNSS Navigation and pos. sys.		✓					✓	
UTM Service provisioning		✓		✓				
Drone operations			✓	✓				
Safety and regulatory assessment					✓	✓		
Requirement analysis and management		✓	✓		✓			
Service design and development	✓	✓		✓				
Aeronautical concept validation			✓	✓	✓	✓		
Communication dissemination	✓				✓	✓		✓

ICARUS – Key Information

- Project Start Date: May 1, 2020
  - Project Kick Off Meeting: June 27, 2020
- Project Duration: 27 Months
- Project End Date: July 31, 2022

Funded under
H2020-EU.3.4.7.

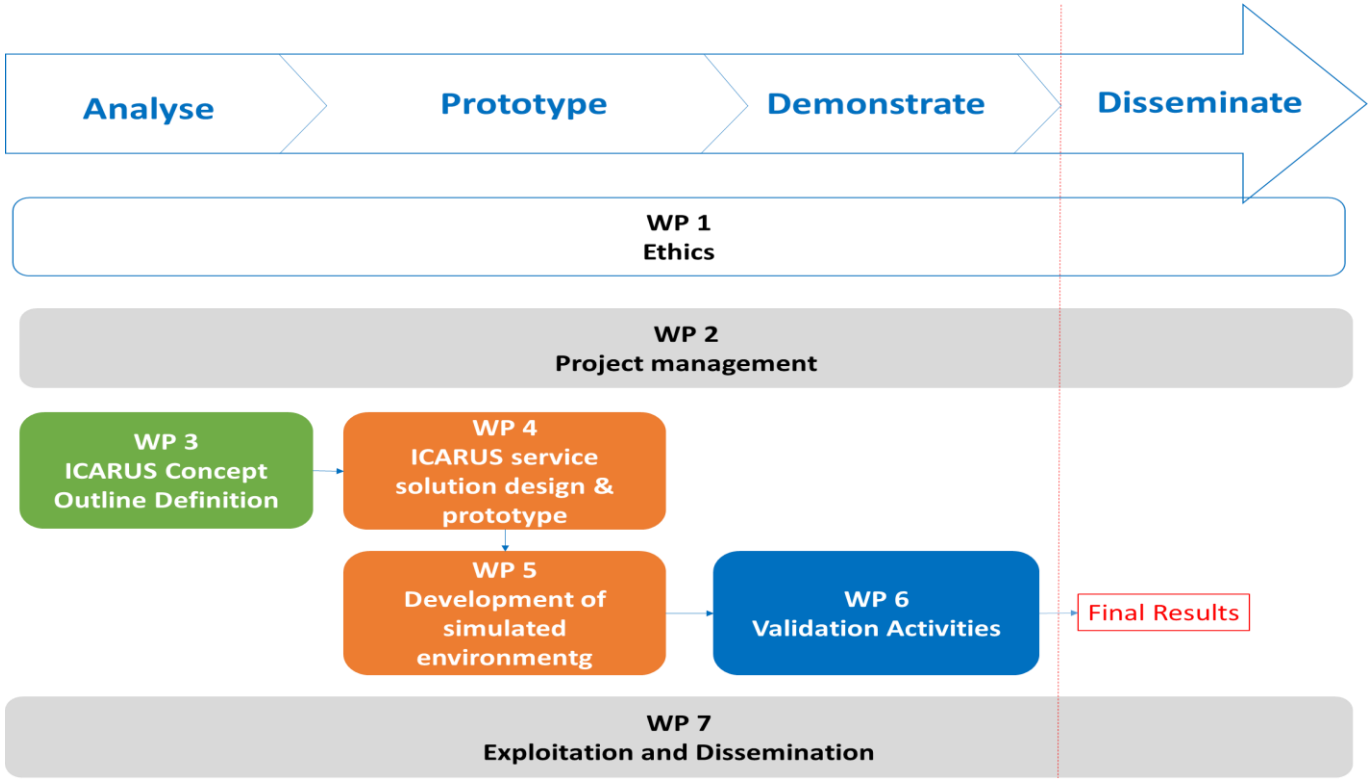
Overall budget
€ 1 385 286,25

EU contribution
€ 1 144 587,50

Coordinated by
E-GEOS SPA

Italy

ICARUS Work Logic



Logical sequence for methodology implementation carried on through the WP phasing

ICARUS – Milestones

ID	Milestone	Date
M01	Kick-Off Meeting	May 27, 2020
M02	**Mid-term analysis Review:** • Project Management Plan – Issue 1 • D3.1 – ICARUS concept definition – Draft Version	October 1, 2020
M03	**Final analysis Review** • D3.1 – ICARUS concept definition – Issue 1 • KOM system/service Design	December 2020
M04	**Architecture Design Review** • D4.1 Design and architecture of the ICARUS system & service	April 2021
M05	System/Service Prototype acceptance Review & Validation scenario design	October 2021
M06	Final Results Review	January 2022
M07	Final Review (with dissemination results)	July 2022

ICARUS Scope

Corrado Orsini **Telespazio**

ICARUS First Advisory Board Meeting - October 28, 2020

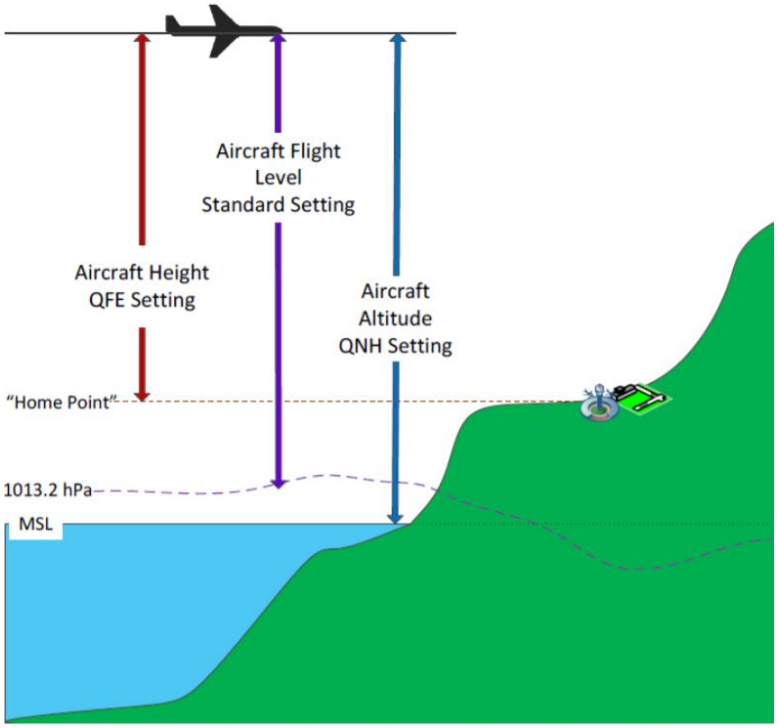
SESAR JOINT UNDERTAKING

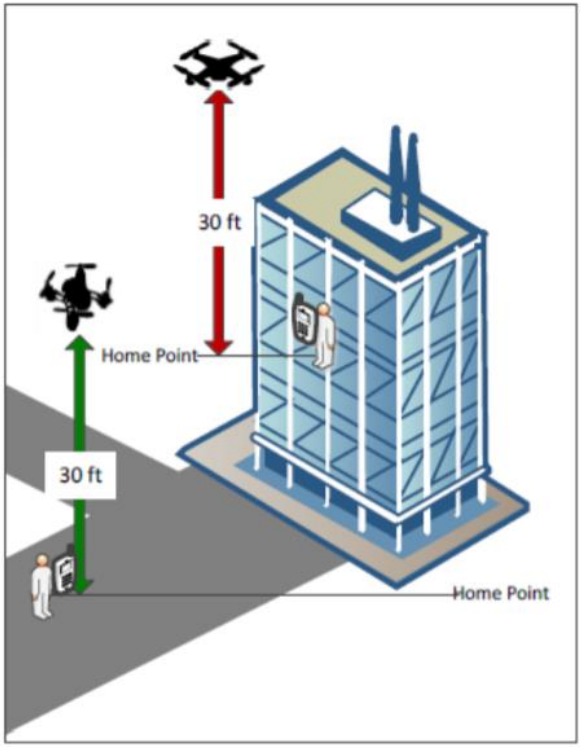
Founding Members

EUROPEAN UNION EUROCONTROL

Problem Statement

1. Which technology should be used to measure the altitude at which a UAS is flying and to what precision,accuracy and integrity?
2. Which procedural mitigations can be put in place in order to harmonize the common altitude reference problem addressed for drones and for the other users of the same VLL airspace?
3. Which reference datum should be used to ensure that every airspace user is flying in the same altitude/height reference system?





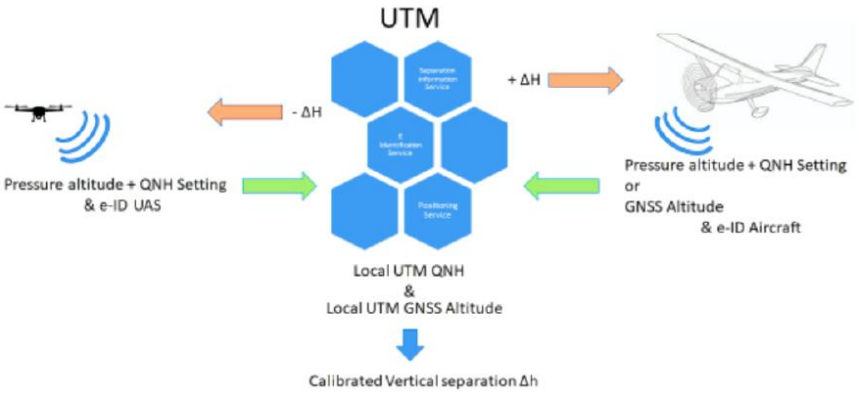
ICARUS Purpose

Icarus represents a **solution** with the aim to:

- Define a **universal flight altitude reference system** based on a **geodetic** approach

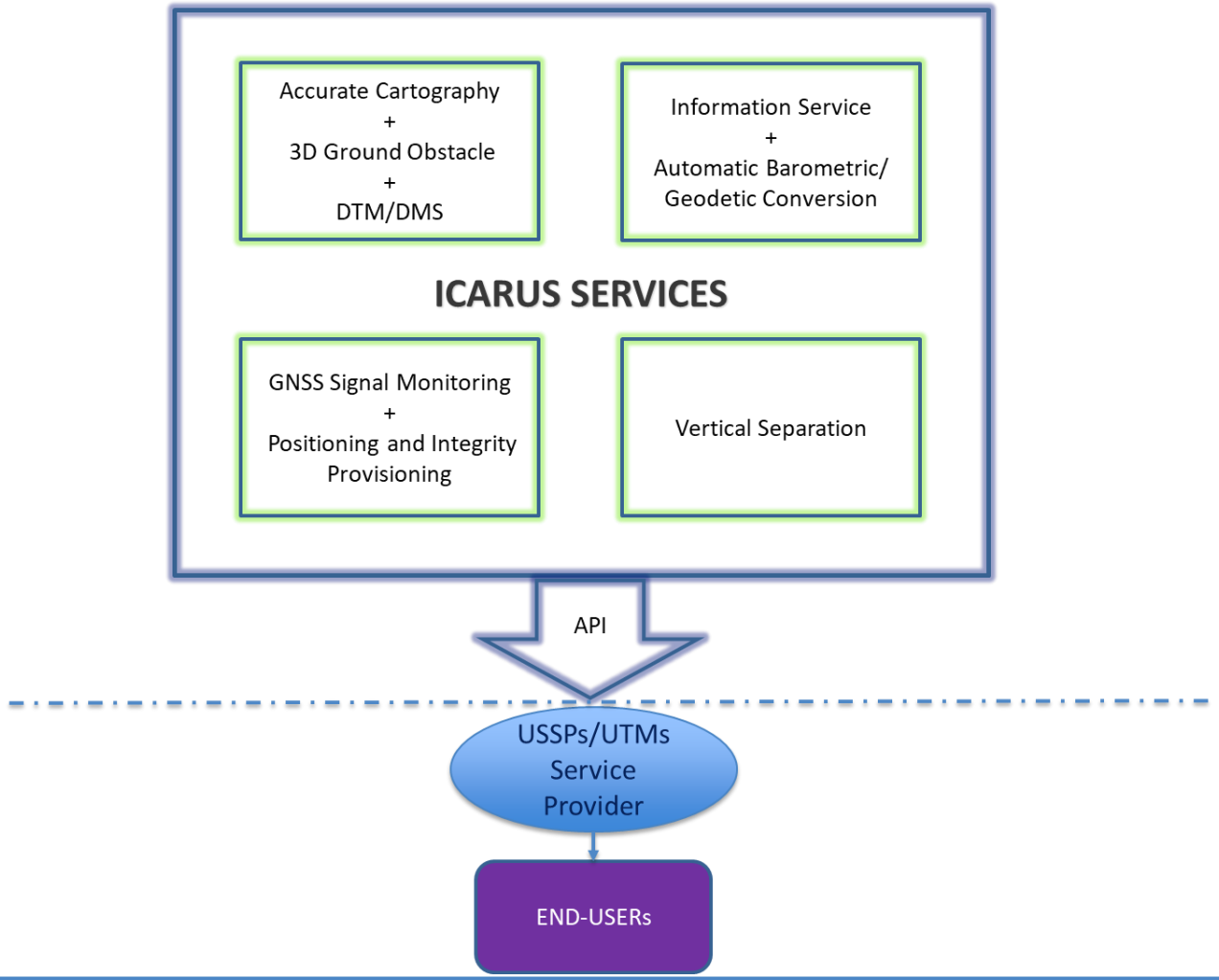
- Provide a **UTM functionality** for strategic and tactical phases giving:
  - **real time information of vertical distance** to ground
  - **conversion of different altitude** reference systems (barometric to geodetic and vice versa)

Addressing **harmonization** and ensuring fundamental bases for **vertical separation** between manned and unmanned in VLL airspace



ICARUS Service

Icarus can be conceived as a **Service** distributed to the end-users (manned and unmanned pilots) as an add-on in the pre-existing UTM platforms through a **tablet application/web application**



ICARUS CONCEPT

The majority of drones make use of GNSS/SBAS dual constellation receivers

ICARUS determine **height using GNSS** in multi-constellation / Multifrequency/ SBAS mode

WGS-84 ellipsoid datum as **standard reference system** used to provide a **common reference zero altitude to all drones & G.A. aircrafts**

ICARUS Provide:

- Sub metric accuracy
- Vertical distance from terrain & ground obstacles
- Strategic and tactical deconfliction from ground obstacle
- Conversion from barometric to geodetic altitude and viceversa for G.A. pilots

ICARUS high level technical objectives

Alberto Mennella TopView s.r.l.

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

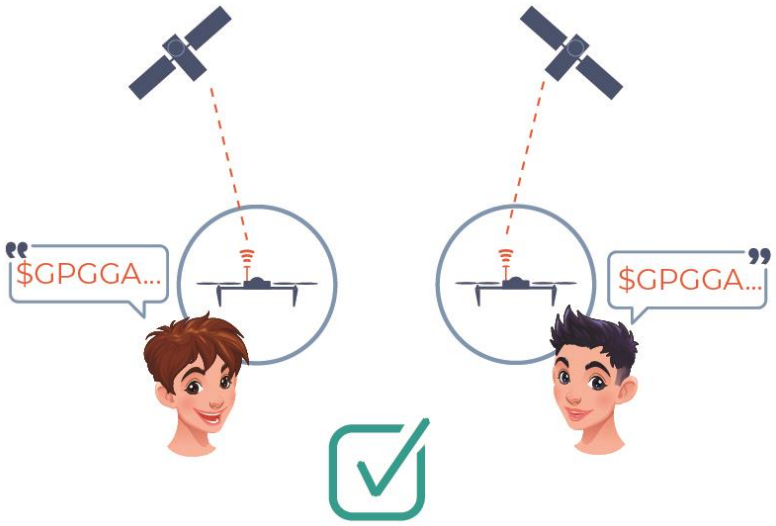
ICARUS High level technical objectives

1. UAS-UAS Common altitude reference at VLL
   - Performance Based Navigation approach;
   - Data Sources: DFMC GNSS Receivers and UAS barometers;
   - Technical requirements & Error budget;

2. UAS-Ground Obstacles awareness at VLL
   - DTM/DSM/DEM state-of-the art models and vertical accuracy;
   - Error budget (Terrain model & WGS-84 datum);

3. UAS-Manned Flight reference
   - GNSS-Barometric translation model;
   - Possible communication mechanisms;
   - Translation service Error Budget;

1. UAS-UAS common reference at VLL



OBJ #1: **To define the technical requirements for high accuracy GNSS-based altitude measurement for drones, allowing a reliable and accurate common vertical reference (UAS-UAS).**

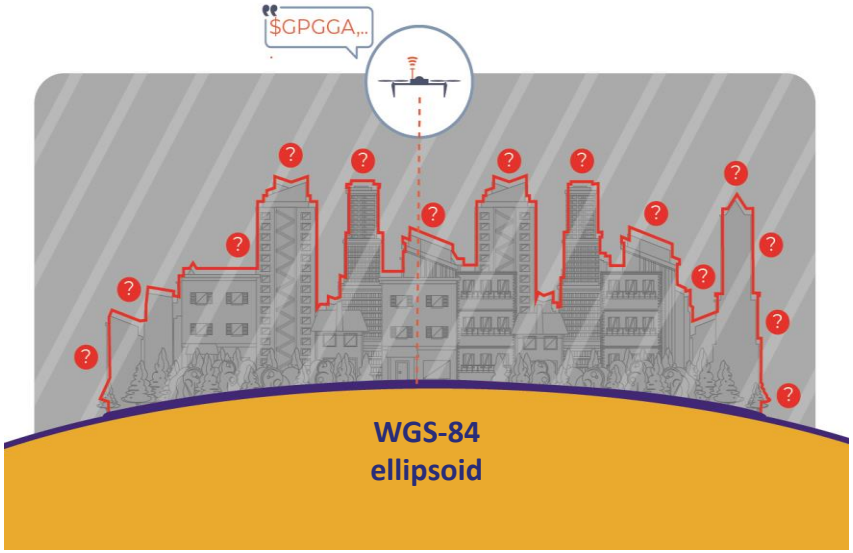
✓DFMC GNSS receivers' requirements for the definition of the main navigation parameters in the determination of vertical component in different operational environments

- accuracy, continuity, availability, integrity (ref. PBN, ICAO doc. 9613 5th edition, ICAO doc. 8168 – "separation", CORUS Conops - ed.3 oct 2019)
- RURAL / URBAN environment
- Controlled/Uncontrolled Airspace
- U-space X, Y, Z_u volumes

✓With respect to the GNSS signal integrity, to identify possible strategies (onboard / U-space service oriented) for the monitoring of GNSS signal performance

✓To explore the added value and differentiators offered by European GNSS constellation GALILEO (OS-NMA, HAS Galileo services impact on the vertical axis)

2. UAS-Ground Obstacles awareness



OBJ#2: To investigate the vertical accuracy and resolutions achievable by the actual DTM/DSM services for ground obstacles and terrain profile, with respect to the geodetic WGS-84 datum

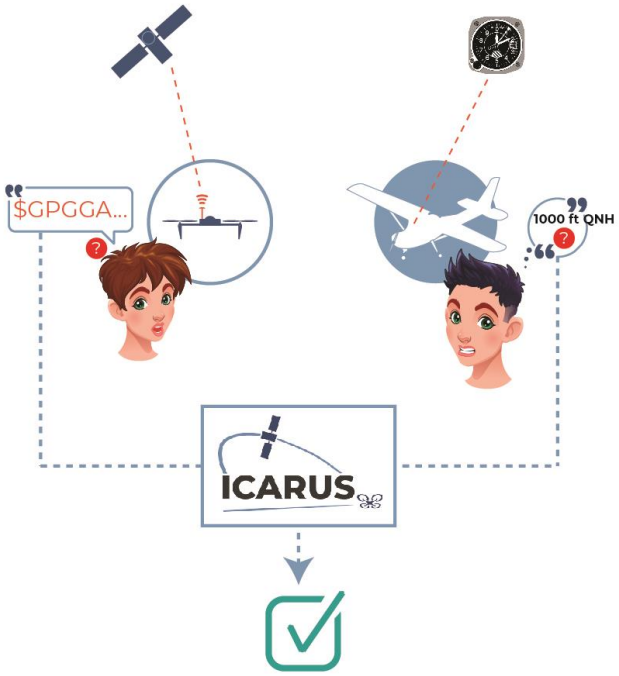
- ✓a common datum based on WGS-84 for UAS vertical separation to ground requires additional information eventually provided by the U-space (mapping service at strategic phase) or possibly achieved by a look-up tables (trade-off: accuracy against size, cost, onboard/ground calculation).
- ✓Identification of actual DTM/DSM available models (Global DEMs, Regionals, European…)
- ✓Error Budget: Transformation errors introduced by the DTM/DSM service with respect to WGS-84 datum must be taken into account

2. UAS-Ground Obstacles awareness

Geocentric Altitude Mandatory Zones (proposal)

- GAMZ (datum: WGS-84) – CTR (datum: QNH)
- «Drone only» zones (i.e. delivery application);
- Temporarly removable by institutional actors (HEMS operations)
- Low Level Routes (i.e. daily routes between two hospitals)

3. UAS-Manned flights Common Reference



OBJ #3: **To design a tailored U-space service for height translation: geodetic measurement to a barometric reference system and vice-versa for UAS and Manned aircrafts**

- ✓ GNSS-Barometric translation model: To define the model underpinning the service.
  - input and output parameters of the proposed service;
  - actors (drone, drone pilot, GA pilot, ultralight pilot,…)
  - additional information needed by the service for real time optimal performances (METAR stations, GNSS monitoring stations network)
- ✓ Communication strategies for altitude translation service delivery with respect to the class of the Airspace (X, Y, Zu, G, D) and the airspace actors expected (i.e. 5G for drones, VHF for GA pilots)
- ✓ Error Budget: Errors introduced by barometric (QNH) / Geodetic (WGS-84) datum must translation must be taken into account

Questions and Answers

11:30 – 11:40 Q&A

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

ICARUS
Digital Elevation Models

Mattia Crespi **DICEA**

October 28 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

Digital Elevation Model & obstacle data products

General definitions (DEM, DSM, DTM, obstacle)

Overview on the presently available (open and commercially) products at global, European and local/regional level

DEMs and obstacles **accuracy assessment principles**

Main addressed questions:

- which are the available DEM and obstacle data products?
- which are their main features and their accuracy?
- are there services providing DEM and obstacle data products?
- are they free or paid services? are they certified services?

General definitions

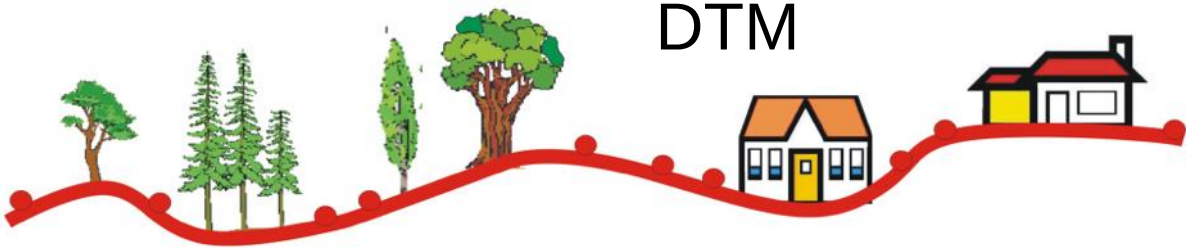
DEM - generic term, indicating the discrete representation of the surface of the Earth using points placed on a regular grid (GRID data format) or, sometimes, irregularly (TIN data format)

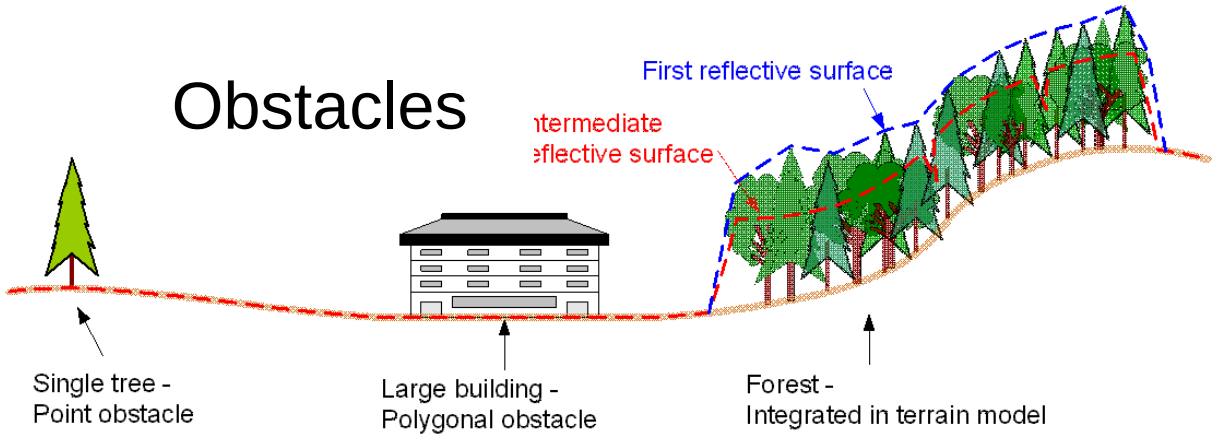
DSM - representation of the Earth **surface as visible from space**

DTM - representation of the surface of the **bare ground**

Obstacle - feature with a vertical significance compared to the surrounding terrain or surrounding features, constituting a potential hazard to aircraft operations

General definitions





Global DEMs

- **SRTM DEM** - https://www2.jpl.nasa.gov/srtm/ - **Free**
- **ASTER GDEM3 and ASTWBD** - https://asterweb.jpl.nasa.gov/gdem.asp - **Free**
- **AW3D30** - https://www.eorc.jaxa.jp/ALOS/en/aw3d30/ - **Free**
- **AW3D Standard** - https://www.aw3d.jp/en/products/standard/ - **Commercial**
- **MERIT DEM** - http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_DEM/index.html - **Free**
- **TanDEM-X** - https://geoservice.dlr.de/web/dataguide/tdm90/ - **Free**
- **WorldDEM™** - https://www.intelligence-airbusds.com/ - **Commercial/Free for scientific research**

No certified products/services

European - Regional/local DEMs

- **EU-DEM** - https://land.copernicus.eu/imagery-in-situ/eu-dem - **Free**
- **Euro-Maps 3D DSM** - https://www.gaf.de/content/euro-maps-3d-dsm-now-also-available-copernicus-data-access-portfolio - **Free**

- **Regional/local DEMs** (e.g. city models) available worldwide through online portals
  - **open (off-the-shelf products)** - OpenTopography, Opendem
  - **commercial (off-the-shelf and on-demand products)**
- On-demand products including **high-resolution (0.1-0.5 m)/high-accuracy (LE90: 0.2-0.5 m)** DEMs from aerial photogrammetric and LIDAR surveys - **updating issue**

No certified products/services

Obstacles

Definition

ICAO - Annex 15 to the Convention on International Civil Aviation - Aeronautical Information Services. Fifteenth Edition, July 2016 (https://skybrary.aero/bookshelf/books/3737.pdf)

Reference documents, with requirements and accuracy specifications:

- Europe - EUROCONTROL - Terrain and Obstacle Data Manual
  https://www.eurocontrol.int/publication/eurocontrol-terrain-and-obstacle-data-manual
- USA - Federal Aviation Administration (FAA) - Obstacle Data
  https://www.faa.gov/air_traffic/flight_info/aeronav/obst_data/

Obstacles should be intrinsically included in a DSM

DEM accuracy assessment

Comparison with a reference DEM

(usually from LIDAR or high scale/high accuracy photogrammetry)

General procedure for DEM assessment **within Google Earth Engine**

Nascetti, A., Di Rita, M., Ravanelli, R., Amicuzi, M., Esposito, S., and Crespi, M.

FREE GLOBAL DSM ASSESSMENT ON LARGE SCALE AREAS EXPLOITING THE POTENTIALITIES OF THE INNOVATIVE GOOGLE EARTH ENGINE PLATFORM,

Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-1/W1, 627–633, https://doi.org/10.5194/isprs-archives-XLII-1-W1-627-2017, 2017.

Accuracy for DEM/obstacle represented with the following **indexes**:

- horizontal accuracy - Circular Error 90% (CE90)
- vertical accuracy - Linear Error 90% (LE90)

ICARUS Architecture

Pawel Korzec **DroneRadar**

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

Due to limited computing power resources on Drones, it is advised to perform H/A conversion using DTM/DSM on EDGE

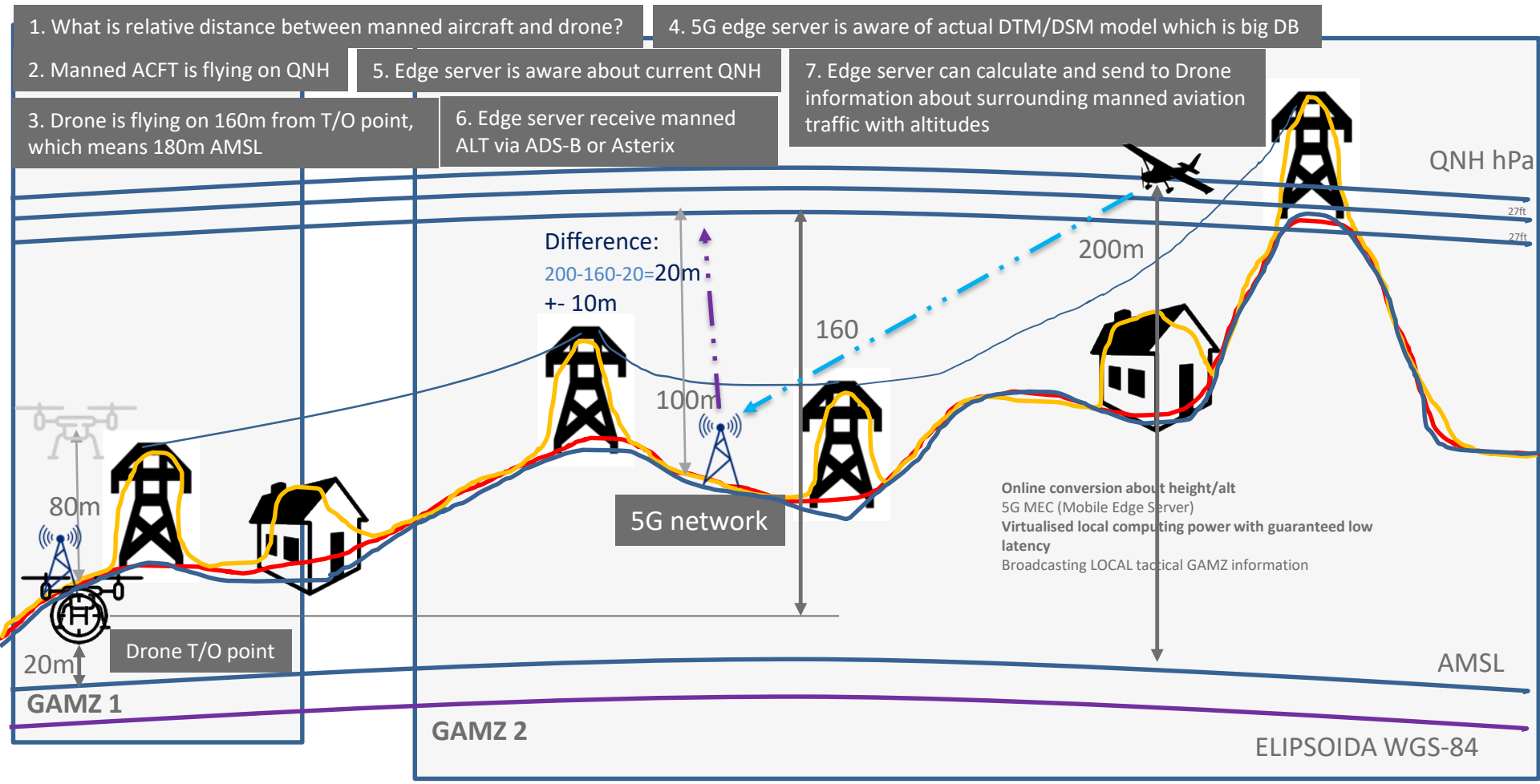
Glossary:
Level (plane or Surface) vs height vs altitude?

DTM -> AGL (aviation)

DSM (Surface model – average)

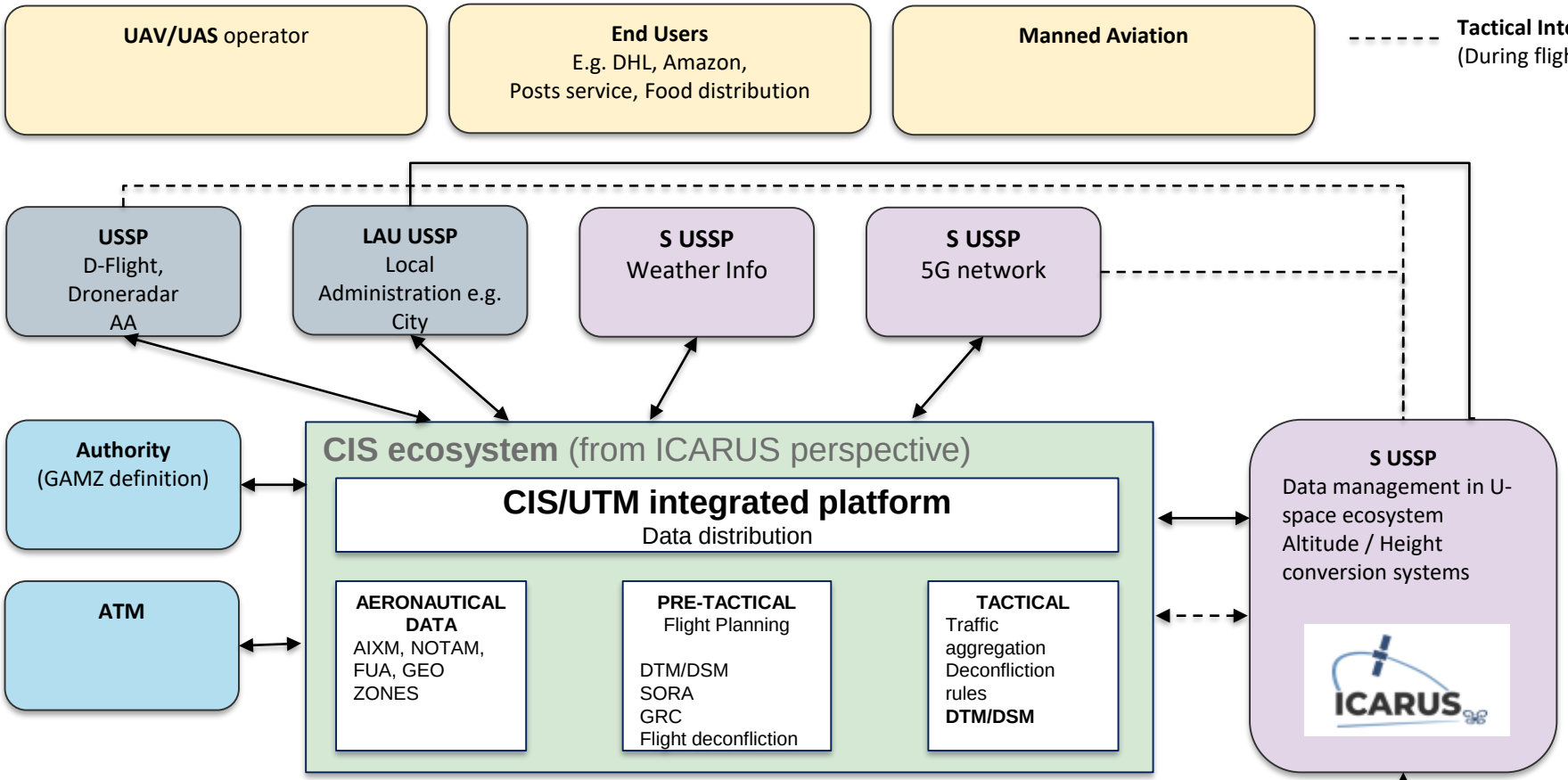
Take-off and landing based on DTM
Transit flights – based on GNSS/QNH with respect to crossing AGL upper boundary (150m)

1. What is relative distance between manned aircraft and drone?
2. Manned ACFT is flying on QNH
3. Drone is flying on 160m from T/O point, which means 180m AMSL
4. 5G edge server is aware of actual DTM/DSM model which is big DB
5. Edge server is aware about current QNH
6. Edge server receive manned ALT via ADS-B or Asterix
7. Edge server can calculate and send to Drone information about surrounding manned aviation traffic with altitudes



WP4 Technical (architecture and prototype)

T4.1 ICARUS system & service architecture



USSP – U-Space Services provider* must provide 4 basic services:
NIC, Geo-awereness, Authorisation, TIS

S USSP (Supplementary) - can provide additional services, but without the requirement of all 4 basic services

* Although in the latest version of ”Regulatory framework for the U-space:" the USSP and Suplementary USSP definitions have disappeared, we have left them deliberately with the note that this concept will probably be maintained.

Questions and Answers

11:00 – 11:10 Q&A

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

ICARUS Real Time Survey

Francesco Russo **TopView s.r.l.**

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

Introduction

Two weeks ago we started an exploratory survey addressed to two **categories** of **users**:

- **Drone** pilots and operators
- **General Aviation** pilots, operators and flight controllers.

Main goal

To **engage** the **people** involved in drones and general aviation in the definition of the ICARUS concept, collecting both qualitative and quantitative data

Real-time survey methodology

We are going to set up a real-time survey with all the participants in this Advisory Board.

Activities to do

1. Take part in the survey using the link in Webex chat
2. 3 minutes to fill the form
3. Answers overview and comparison with the partial results of the users' surveys

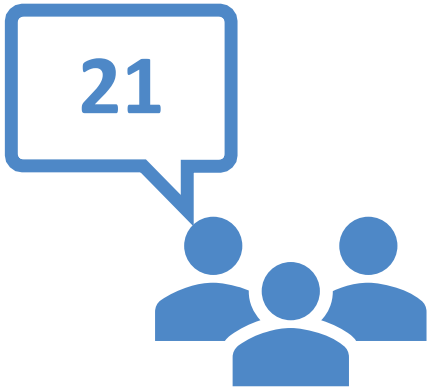
Q&A

Please note: all questions will be answered in the open discussion

Real-time survey

Time and responses

3 minutes



Responses collected

ICARUS Communication & Dissemination

Manuel Onate **EuroUsc-Es**

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

Communication and dissemination

- A key objective of the ICARUS project is to engage future users and other stakeholders, by:
  - ✓ Describing the **limitations** of the current vertical estimation technologies
  - ✓ Explaining the **concept** of the ICARUS service
  - ✓ Showing the **advantages** that will be provided by the service, in terms of added safety and capacity
- Focus on **online channels and tools**:
  - ✓ Project **website**
  - ✓ Social **media**
  - ✓ Explanatory **videos**
  - ✓ Downloadable non-technical **documents**, white papers and flyers
- The biggest challenge is to **engage traditional aviation actors**, especially from General Aviation

Social media impact

Tweets

9

Profile visits

1473

Audience reached
(Average daily impressions)

2900

Most engaging content

Brochure release

Survey launch

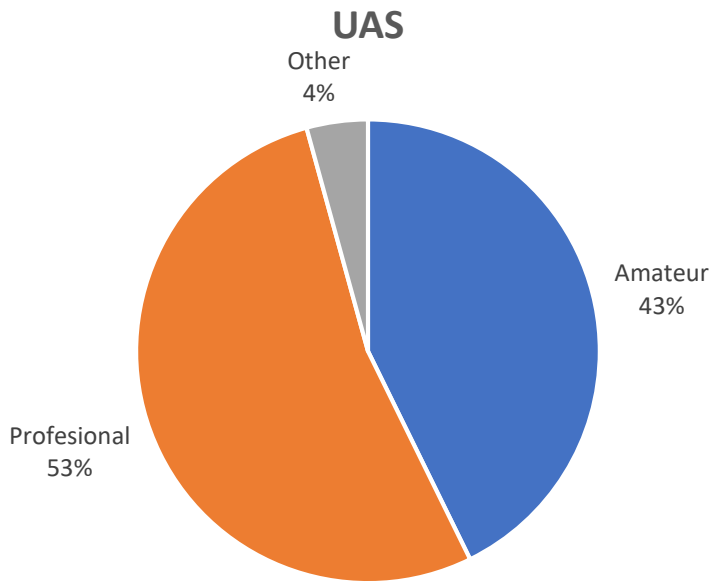
Online survey participation

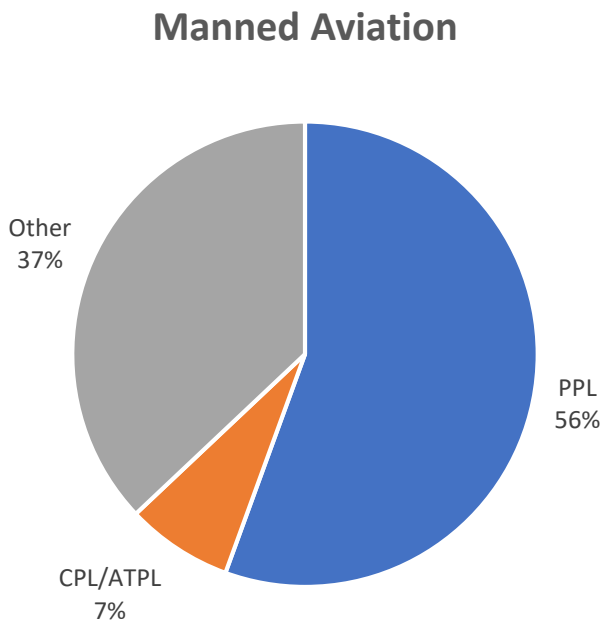
Good response in the first two weeks from the UAS sector:

- 117 answers
- Good representation of amateurs and professional

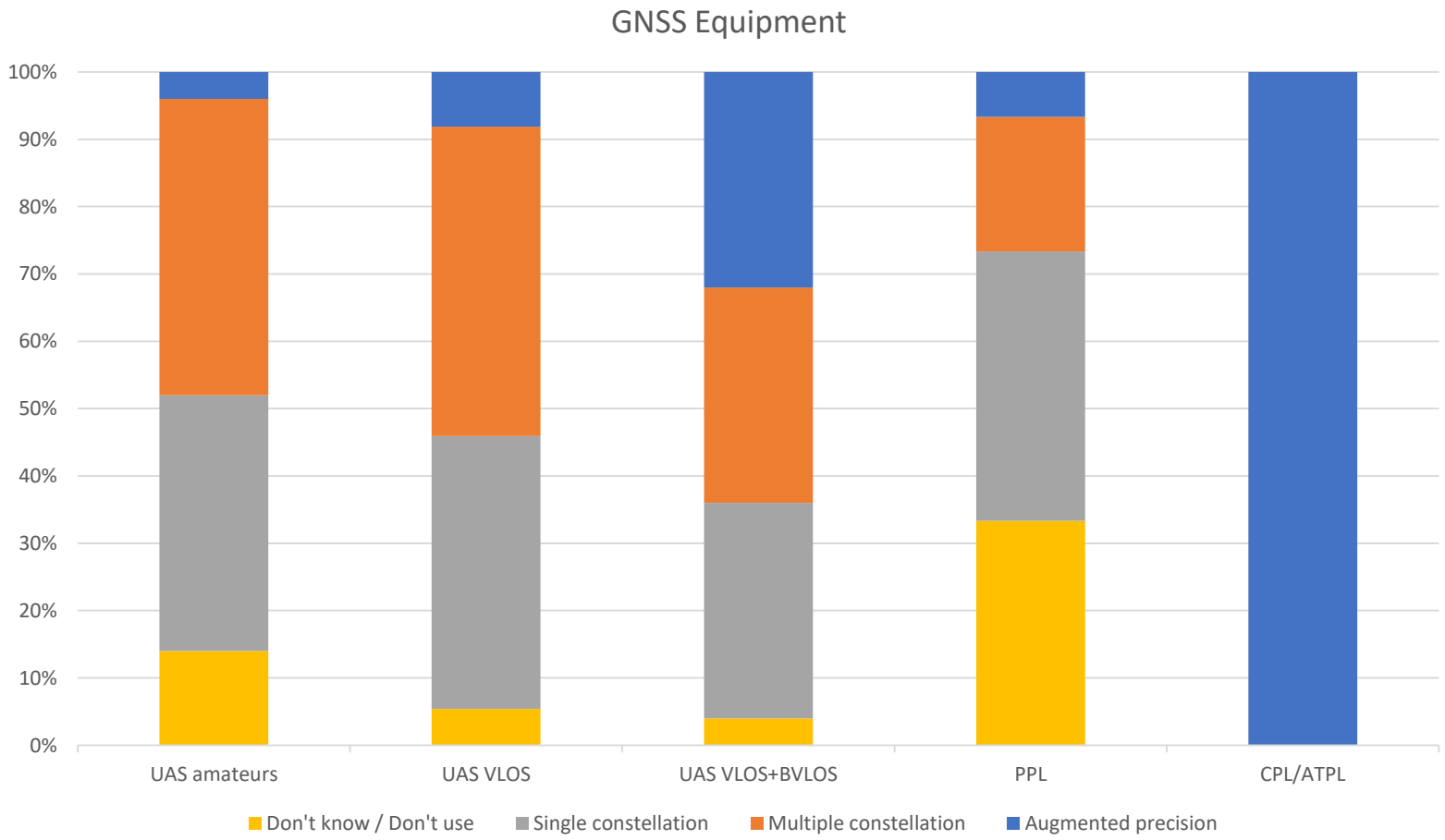
More **help required** for the manned aviation sector:

- Only 27 answers
- Ultralight and LAPL pilots not represented

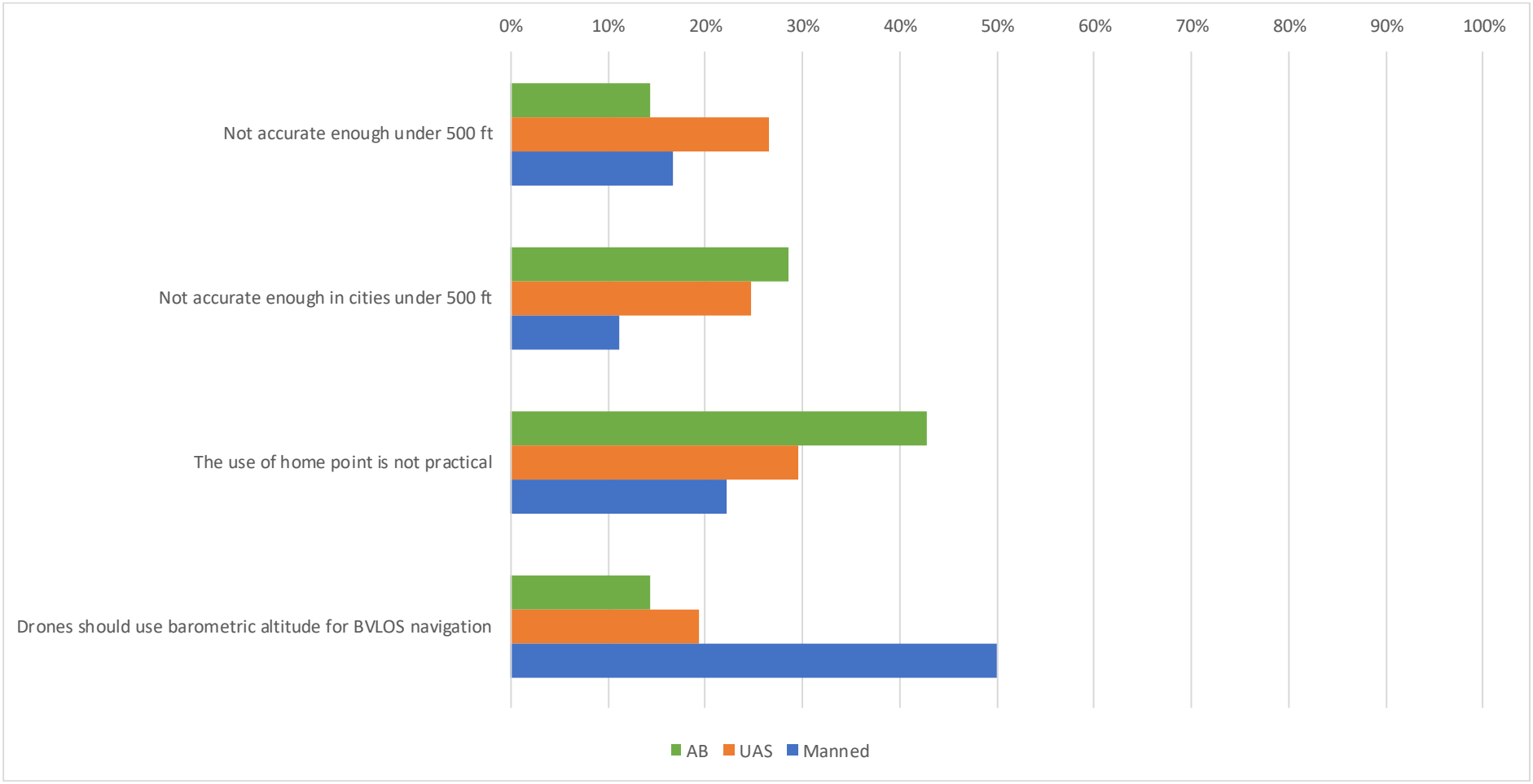




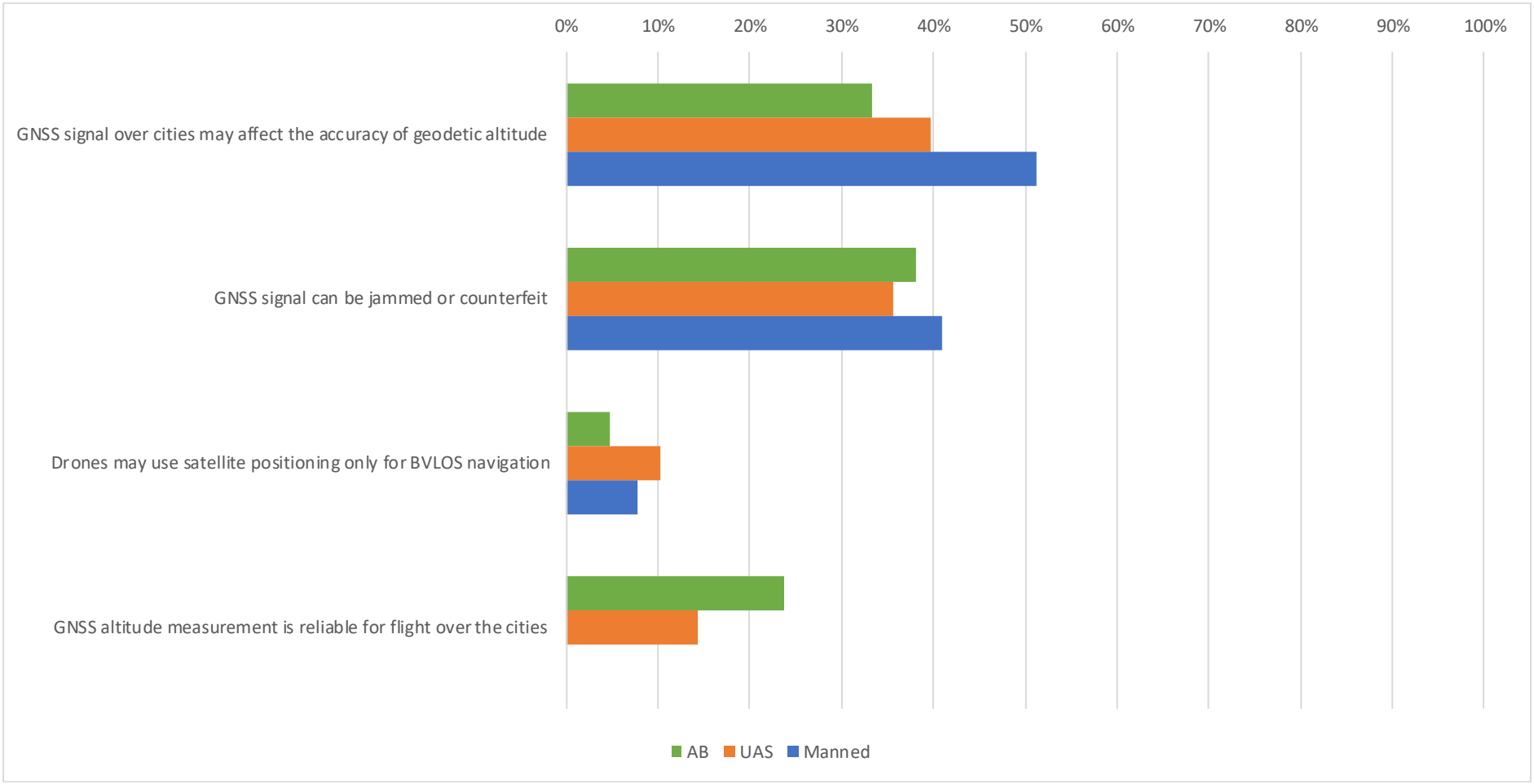
GNSS equipment



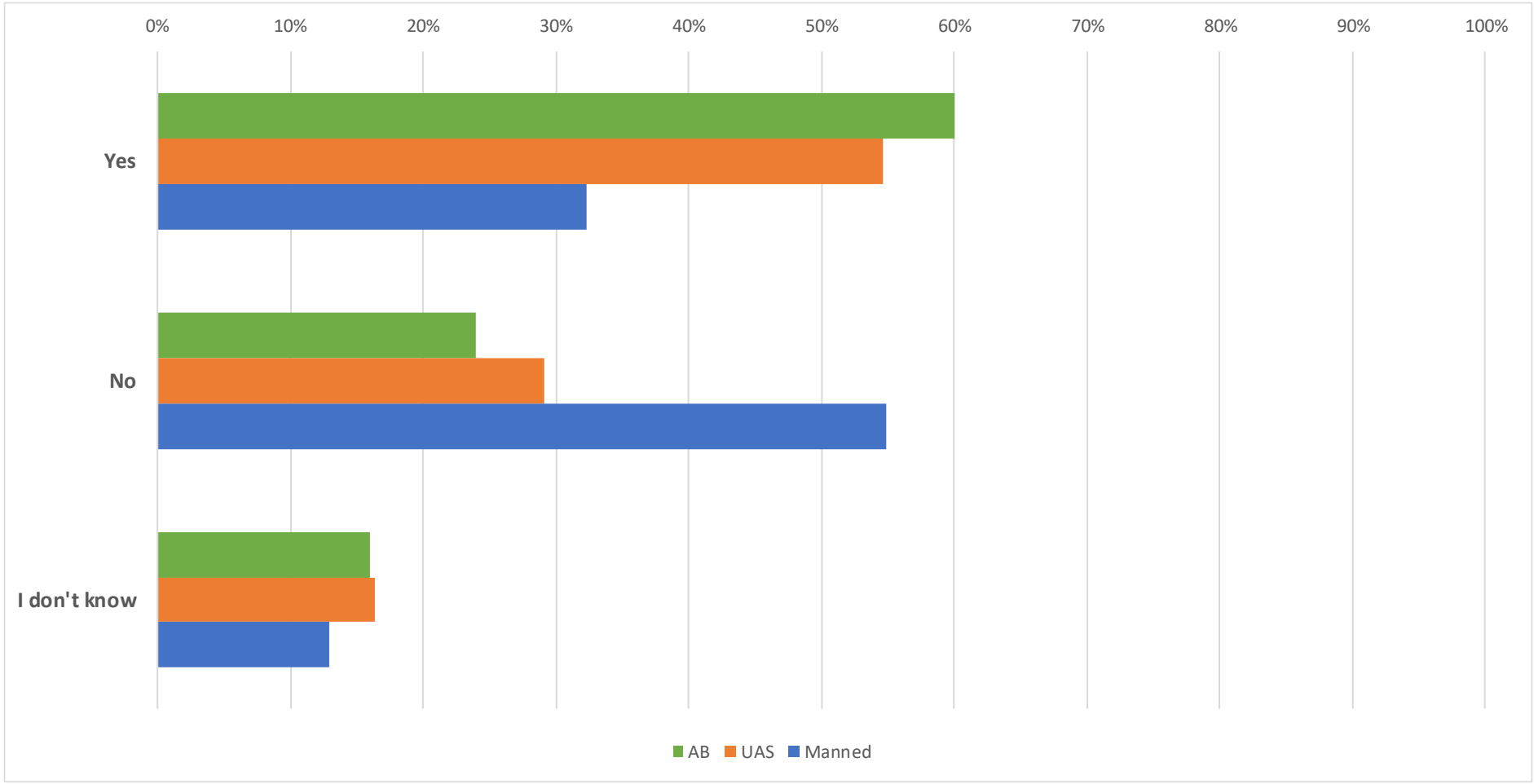
Issues related to barometric altitude



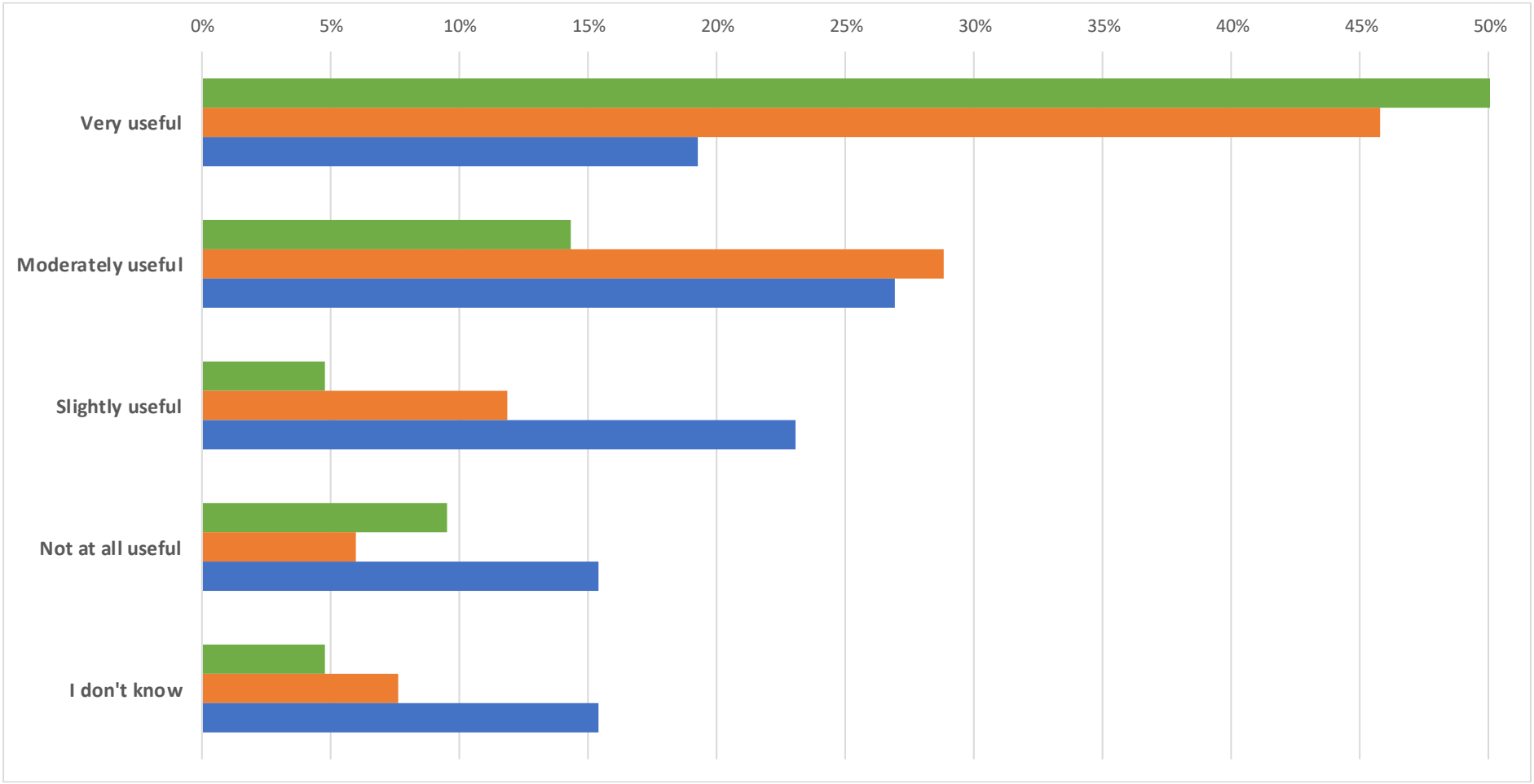
Issues related to GNSS altitude



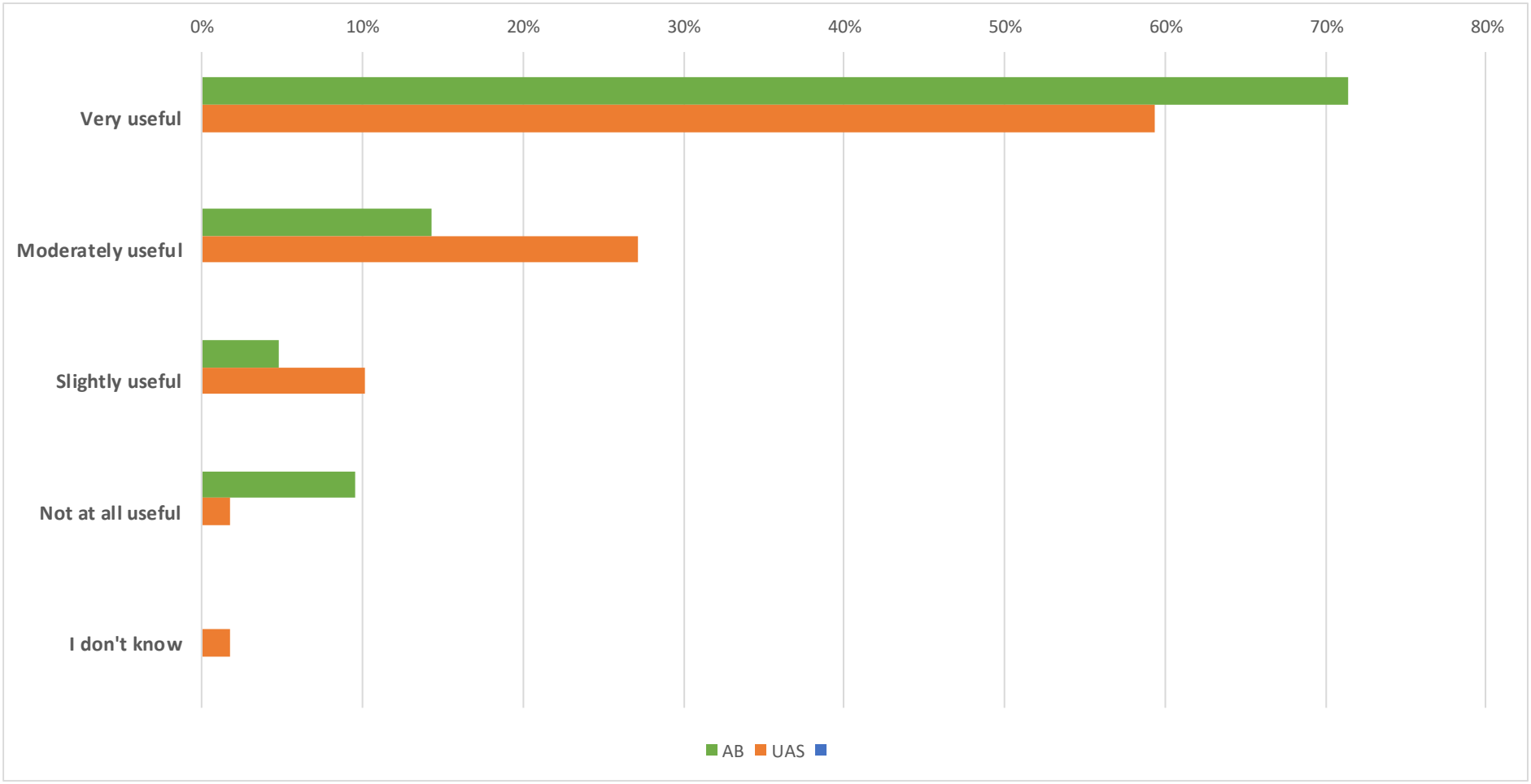
Do you agree with the GAMZ proposal



Real time translation service



Report the presence of ground obstacles



Selected noteworthy feedback

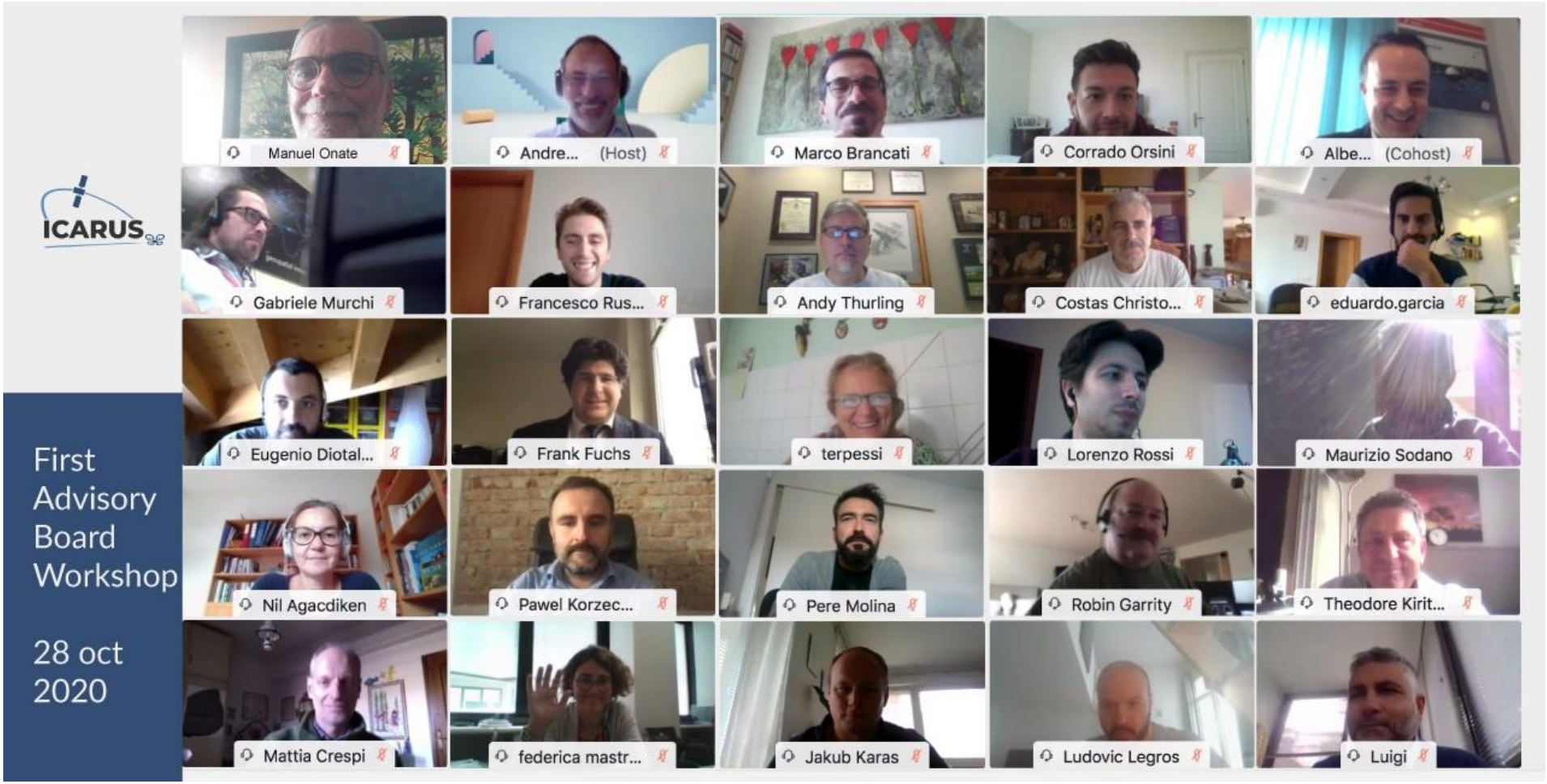
The UAS sector seems to like the project …

- Nobody could think of it when the first drones appeared on the market. The strong growth of drone market makes it a "must“
- How to join?
- I personally prefer to use QNH barometric but I understand that using a CARS is easier for amateur pilots and [those] who fl[y] rarely

The manned aviation sector, not so much …

- This should be treated as navigation support only, not reliable source of information, especially about your vertical position.
- I can't see sufficient economical gain for the aviation industry to balance additional risks related to this solution … statistics show that very often new solutions in aviation can cause fatal accidents … if something works, why should we change [it]?
- Could lead in increasing workload for ATCOs because they should manage different altitude references in the same area at different levels
- We need more discussion about [CARS]

Family photo



ICARUS – Open Discussion

12:00 – 12:25

ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

ICARUS – Roadmap and next meeting

Cristina Terpessi **e-Geos**

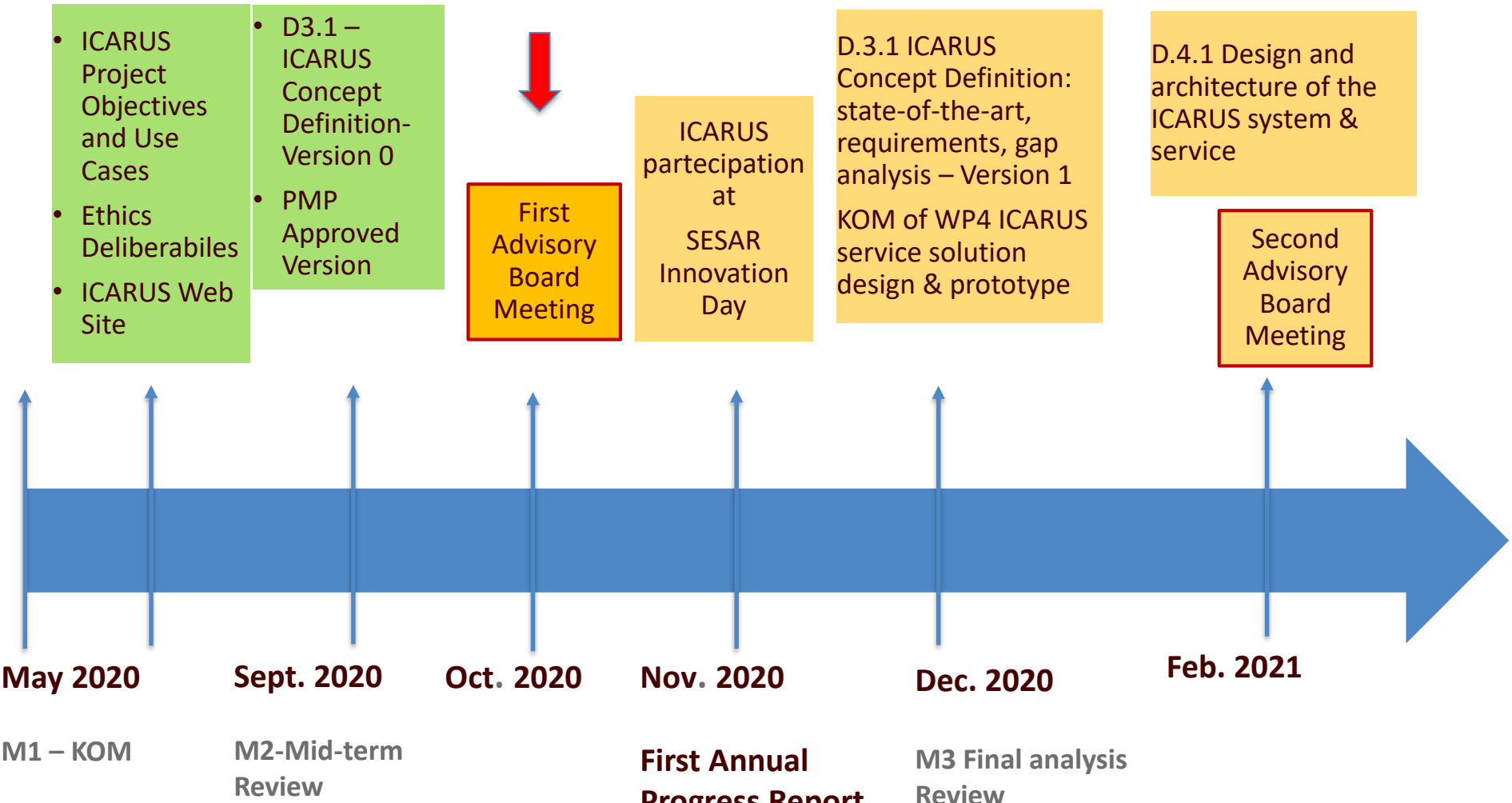
ICARUS First Advisory Board Meeting - October 28, 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

ICARUS Short-Term Roadmap



U-space ICARUS Project

Thank you very much for your attention!

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No [number]

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL